Urban Heritage Resilience 3.0 An Integrated and Operationable Definition from the SHELTER and ARCH Projects

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Article

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Abstract: Resilience, initially a concept rooted in psychology, has traversed disciplinary boundaries, finding application in fields such as urban planning and development since the 2010s. Despite its broad application, most definitions remain too abstract to allow their practical integration into urban planning and development contexts. Addressing this challenge, the H2020 projects SHELTER and ARCH offer a practicable integration of resilience with planning and development practices surrounding urban heritage. Following a systemic approach to resilience, both projects integrate perspectives from urban development, climate change adaptation, disaster risk management, and heritage management, supported with tools and guidance to anchor resilience in existing practices. This paper presents the results from both projects, including similarities and differences.

Keywords: urban heritage, resilience, urban planning, climate change, urban development, sustainable urban development

1. Introduction

Urban heritage is a system of tangible and intangible heritage, including dimensions of use and functions as well as communities and users. The ultimate purpose of urban heritage is to increase the quality of life of these communities and users [1]. This necessitates management approaches that integrate principles of sustainability and resilience. Sustainable practices, such as the preservation and adaptive reuse of historic structures, not only conserve resources but also diminish the environmental impact linked with new construction, contributing to a more sustainable urban environment. Additionally, embracing resilience in the management of urban heritage acknowledges the dynamic nature of communities and equips them to effectively confront and recover from challenges. Intangible aspects like cultural traditions and social bonds play a pivotal role in fostering resilience, fortifying the community's ability to withstand adversities [2].

While the concepts of sustainability and resilience have seen an increased use in high-level strategies (see e.g., [3]) on international (e.g., [4–6]), national (e.g., German Resilience Strategy [7]), and local levels (e.g., Rockefeller 100 resilient cities program [8], UN Making Cities Resilient Campaign [9]), the concept of urban resilience remains too abstract and lacks sufficient detail to be implemented on the operational level, hampering the development of tailored actions that go beyond abstract strategic goals. To make the concept of urban resilience more operationalizable in our cities we need to better connect it to practices of urban planning and management, while keeping a sufficient degree of universality to ensure replicability.

To implement such a necessary cross-sectorial concept of urban resilience a common understanding of it is needed. From the range of different definitions that co-exist, Meerow et al. provide a suitable starting point for further elaboration: "Urban resilience refers to the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal

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and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity."[10]

The research question of this paper is: How can a concept for urban resilience be described, that is operationalizable and applicable in urban planning and at the same time reflects the various roles of urban heritage related to resilience? The paper aims to propose the SHELTER and ARCH frameworks as a concept on a medium level of detail with enough universality that can be communicated to the wide range of stakeholders that are part of the urban governance systems.

2. Materials and Methods

2.1 Systemic Approach to Resilience for Urban Planning and Urban Heritage Management

A systemic approach is based on the understanding of the real world being organized in systems. Instead of focusing on singular entities, the systems approach considers the dynamic, complex, and non-linear connections and interdependencies between the different elements of the system implementing a far more complex but at the same time more realistic view of phenomena. [11]. The governance in these complex systems must be multidisciplinary and different from more traditional unidisciplinary problem-solving approaches [12], e.g., via more adaptive approaches embracing uncertainty [13]

The term resilience can be traced back to the 15th century as a juridical term for the restoration of the original legal situation. It is not until the 19th century that it related to the physical qualities of the material to withstand something (Psychology integrated the term only in the first decades of the 20th century and connected it with emotional/psychological stability which was also linked to the concept of homeostasis [14,15]. One milestone in the rise of the popularity of the term was a study that explored children from difficult families where the ability to deal with and overcome obstacles was described as resilience [16]. The systemic nature of resilience makes the concept highly transferable. In the second half of the 20th century, the term resilience was transferred to other disciplines such as biology [17]. Since then, resilience has been examined in family systems [18], food systems [19], education systems [20],communities [21], cities [22] (or even in a global scale taking mankind into account [23].

There are different views of resilience as a vision from a systemic evolution lens and self-organization [24]. The work of Folke (2006) describes the evolution of the resilience concept from a linear engineering perspective, where the objective is to return to the initial hypothetical status, to a much broader, humanistic and comprehensive one where the objective is the adaptation and transformation of socio-ecological systems to a more sustainable status [25].

The understanding of urban environments as socio-ecological systems (process-dependent, multidimensional, multiagent, multiscalar and with self-organizing capabilities) has deep implications for their resilience enhancement, as it requires a change from mechanistic and linear views to a more systemic vision of their resilience. The assessment of the resilience of urban environments must be done within the larger socio-ecological system, though the size of the systems and subsystems (defined by their borders, where it usually becomes interesting) can vary. This vision must jointly address specified and generalised resilience to not lose resilience in parts of the system or its subsystems [26]. Specified resilience is the ability of a socio-ecological system to address specific hazards or hazard combinations impacting specific components, usually addressed via technological-structural solutions. In this more short-term, system intrinsic, and hazard-specific context, risk and vulnerability assessments can use direct quantitative and spatial approaches for prioritization and identification of specific "hot spots" making it especially beneficial for the protection of urban heritage (conservation-friendly resilience). Generalized resilience is the long-term, transformative ability to address all kinds of shocks and disturbances (including unknown ones) [27], usually also integrating "soft" social-cultural solutions. General resilience is a blurrier concept, dependent on the vulnerability of the system but also related to the development of adaptive, learning, and self-organization capabilities. As such, its quantitative assessment and operationalization is more difficult. But it can also act as a transdisciplinary bridge [28] that can unify the fields of Disaster Risk

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Management, Climate Change Adaptation, and Sustainable Urban Development ([29,30]). It can be suitable for a heritage-led resilience enhancement assessment (see e.g., the ARCH Resilience Assessment Dashboard, [31,32]), because of its focus on the transformation processes (how societies cope with uncertainty, adapt to new situations, and transform to new environmental, social, and economic conditions to make the new system more sustainable while retaining their identity). Addressing both concepts is important since practitioners tend to focus only on specified resilience narrowing options for dealing with new hazards and shocks [28].

2.2 Sustainability vs resilience

Closely related to the concept of resilience is the concept of sustainability. Sustainability emphasizes the responsible use of resources and the creation of systems that endure over time, fostering a balance between present needs and the preservation of resources for future generations [33]. The relationship between sustainability and resilience lies in their shared goal of creating robust and enduring systems. Key differences between the concepts of sustainability and resilience can be seen in **Error! Reference source not found.**.[17]

Table 1.Comparison between sustainability and resilience ([17]p. 101)

Concept	Sustainability	Resilience
Background	Forest Management. Example: 18th century Germany.	Psychological Resilience: the ability to bounce back from a stressful or adverse situation. Theoretical basis developed in the United States in the 1950s.
Objective	To maintain the overall natural resource base.	To make systems flexible enough to deal with changes without changing their principal character.
Definition:	Premise: Everything that we need for our survival and well-being depends, either directly or indirectly, on the natural environment. Process: To create and maintain the conditions under which humans and nature can exist in productive harmony, thereby enabling the fulfilment of the environmental, social, and economic requirements of present and future generations.	The ability of a system to respond flexibly to situational changes and negative factors without changing the essential state.
Type	Primarily linear	Dynamic system
Trend	To enable economic development without damaging the natural resource base.	To stimulate flexibility, adaptability, and risk-preparedness to deal with sudden or long-term changes.
Complexity	Fair	High
Level of Integration	Semi-integrated	Integrated
Parameters involved	Limited number	High number
Implementation	Management and Development Plans, management mechanisms, etc.	New governance models. Change of attitude and values. Empowering communities. Prioritization of cross-cutting topics, initiatives, and developments

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Albeit their conceptual differences, sustainability and resilience represent complementary aspects of a holistic approach to address the complex challenges in socio-ecological-technical systems [34]. A sustainable system, by its nature, tends to be more resilient because it is designed to withstand changes, shocks, and uncertainties without compromising its long-term viability. Conversely, resilient systems often incorporate sustainable practices to ensure their adaptability and persistence over time. Together, sustainability and resilience form a synergistic framework that promotes not only the responsible use of resources but also the ability of systems to withstand, recover, and thrive in the face of challenges, thereby contributing to the overall well-being of communities and the planet.

2.3 Understanding Cultural Heritage for the Operationalisation of Urban Resilience.

Similarly, to the concept of resilience, the evolution of the concept of cultural heritage and its management has deep implications for the operationalisation of urban resilience. What we understand today as cultural heritage and how we use and connect it on a theoretical and practical level has significantly changed during the last decades. Evolved from a focus on single buildings and built heritage, today what we understand as cultural heritage has become more: "(...)'*heritage' (is seen) as a social and political construct encompassing all those places, artefacts and cultural expressions inherited from the past which, because they are seen to reflect and validate our identity as nations, communities, families and even individuals, are worthy of some form of respect and protection"*[35]

With the professionalization of the heritage sector in the 20th century and the growing number of heritage assets (with new categories of cultural heritage), the concept and understanding of cultural heritage have changed significantly, acknowledging its complexity. From the traditional sectorial or one-dimensional approach to a new transversal, multidimensional, community-oriented, dynamic and systemic that aligns different policy areas and resources [36]

This evolution in the understanding of cultural heritage has forced the evolution of the conservation of built heritage, together with the heritage sector: from protecting individual monuments to addressing complex historic environments, from the interest in tangible heritage (with the minimum intervention as an objective) to conservation based on active participation (with priority to people's well-being) [37]. Therefore, nowadays, three different paradigms coexist in parallel with different but compatible focal points: *preservation* with a focus on authenticity, *conservation* centred on adaptive reuse and *heritage management* with a focus on the meanings and experience (Ashworth, 2011). Janssen et al. identified also three different approaches that have emerged: *conservation as a sector* (silo-thinking where built heritage issues are different from spatial development), *conservation as a factor* (built heritage is considered as a resource) and *conservation as a vector* (built heritage is the starting point for sustainable spatial development). Although they have evolved separately, they are all equally relevant today [2,38]. As result, the preservation of buildings and monuments cannot be separated anymore from their use and urban context [39] and a holistic and systemic understanding is required [1].

Parallel to this process, the role of local communities and practices like participation become more relevant [40]. A milestone was the adoption of the Framework Convention on the Value of Cultural Heritage for Society as it articulated a sea of change in perceptions and reframed the role of local communities and use values in heritage. The convention states that the objective of the conservation of cultural heritage *is the "human development and quality of life* "so there is "*the need to put people and human values at the centre of an enlarged and cross-disciplinary concept of cultural heritage*" ("Faro Convention"[41]).

This contemporary understanding of cultural heritage is comparable to the systemic approach and the theoretical concept of resilience [1,42,43]. Therefore, within this new paradigm, the operationalization of resilience in cultural heritage environments cannot be linear but a dynamic and iterative process influenced by forces across spatial and temporal scales where sustainable management of change is required and the ordinary dynamics of historic environments must be combined with exceptional changes due to extreme events. This systemic understanding of cultural heritage is consequently demanding planning and development concepts that are fully

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operationalizable within these systems and are not solely focused on material aspects of the conservation of built heritage.

2.4 Urban Heritage As a Resource: Operationalisation of Heritage-Led Urban Resilience

Urban heritage in the past has often been seen as an obstacle to resilience [15]. The interpretation of the role of cultural heritage in urban resilience as values that must be protected could be understood as an artificial limitation rooted in linear-thinking approaches. The development of a more contemporary understanding of the role of cultural heritage allows the understanding of heritage as a resource for resilience, through a more comprehensive interpretation of their values, that considers not only traditional intrinsic or art-historical values but also the community-based or use values [1,44]. Moreover, the contribution of cultural heritage to resilience must be considered as part of the intrinsic values of the assets regardless of their official status [17]. This contribution can be understood along four different axes: through design and construction; the use of appropriate materials; adaptive use; and factors in urban planning [15]. At the same time urban heritage must be understood as a sub-system of the larger urban environment, including local communities, as well as functions and use[45]; much more than a simple collection of (listed) built heritage. By acknowledging it as a system that includes users, uses, functions, etc. it is following a systemic understanding that is also present in the concept of resilience.

Historic environments are singular from a vulnerability and resilience perspective. They have inherent resilience characteristics that have been tested for centuries, which can trigger a cultural and natural heritage-led resilience enhancement, but also specific characteristics that make them more vulnerable to hazards and disruptions, which make conservation-friendly resilience necessary.

The following table summarizes some of the resilience characteristics gathered from the literature and its implications for a heritage-led resilience in urban heritage (see **Error! Reference source not found.**):

Table 2. Summary of characteristics describing the notion of resilience and their implications for SHELTER

Characteristics of the notion of resilience	Literature	HERITAGE-LED RESILIENCE
Robustness Strength	[25,46–49]	The survival of the historic cities until modern times shows the capacity of these environments to recover from past disasters. The social memory and local knowledge resulting of this history has to be gathered and operationalised.
Flexibility Adaptability Adaptive Capacity Learning capacity Autonomy Room for autonomous change Reflexivity	[3,25,50–56]	Historic environments are results of evolution processes to adapt to the requirements of each epoch. The strategies to improve resilience must include and respect the result of these processes (local techniques, selection of materials and construction cultures) but they also need to learn from the flexibility and adaptability of changing conditions that create these results.
Living with uncertainty Social memory	[57–59]	Generalised resilience requires to learn to live with uncertainty ("expecting the unexpected") and to build a memory of past events to build the capability to learn from crisis and disasters. Long-enduring urban environments have developed adaptations to deal with these disturbances, using social memory as key part of the system resilience.

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Self-organisation	[60–62]	During a significant part of their story, historic cities have been an example of urban self-organisation. Like nature's cycles involving renewal and reorganization the resilience of a system is closely related to this capacity for self-organization.
Diversity Variety Inclusive Fair governance Collaboration Social capital	[53,63,64] [52,61,65]	In ecological systems, diversity provides the conditions for new opportunities in the renewal cycle so the diversity of stakeholder's partnership and arrangement already created around the heritage conservation can be used to bring diversity of views and considerations into the discussion expanding the role of information, education, and dialogue.
Cross-scale dynamic	[25,59]	Response to challenges as climate change and disasters require building cross-scale management capabilities, like the ones necessary for urban conservation.
Resourceful Efficiency	[52,53,64–66]	Historic areas have shown effective ways to construct and design functional urban environments with local and durable materials. New resilience strategies should manage the changing process to keep this identity, considering issues such as maintenance, life cycle, durability and compatibility of the materials, local construction techniques…considering the singularity of cultural heritage's physical vulnerability framed in a broader concept of multidimensional resilience
Intersectorality Integrated	[52,66]	Urban conservation policies and strategies always required integrated visions to include all the needed competences. The improvement of resilience in historic areas is going to need to continue with this tradition and include new department and sectors in the decision making.
Innovation Combining different kinds of knowledge for learning Interdependence	[53,61,67]	The cultural heritage field has always needed the combination of different kinds of knowledge. The focus on the complementarity of this knowledge can help to increase the capacity to learn. Climate change and urban conservation can be used as an example to illustrate the potential contributions of local and traditional knowledge.

The operationalisation of the urban resilience concept to close the gap between theory and practice has been one of the main objectives in the resilience literature of the last few years. Specifically, the resilience phenomenon in historic environments was until recently not effectively approached or even theoretically supported [68]. Resilience is a multi-faceted aspect, so a framework for its operationalization should address all the different dimensions of an urban system [24]. The first step to building a framework to make the concept of resilience operative for urban heritage is to identify the different layers to be considered. Parson el al. (2016) identified the following dimension for urban resilience: social character, economic capital, infrastructure and planning, emergency services, community capital, information and engagement, governance, policy and leadership, and social and community engagement [69]. For historic environments in particular these dimensions can be grouped as follows:

- **Historic building environment resilience:** How the historic building environment addresses disruption, affordable comfort, structural security through traditional techniques, vernacular architecture and built/unbuilt environment relationships and its relevance as container and management unit for other cultural heritage scales (as movable cultural heritage)

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- **Cultural resilience:** How historic areas address social inclusion and support social and technical innovation through cultural identity, local knowledge, intangible cultural heritage, and openness to exploring novel pathways.
- **Social resilience**: How individual's physical and psychological well-being are addressed within the historic area and strong and healthy personal relationships, connection to culture and nature and learning and sharing of new skills are enabled.
- **Governance and institutional resilience:** How links and partnerships are created and managed with support networks and across sectors (including public sector/government, research, and business)
- **Economic resilience**: How well the local and regional economic sectors can make use of competitive advantages as well as their ability to innovate, experiment, and restructure [70]
- **Environmental resilience**: How historic areas traditionally enhance biodiversity, cut carbon dependence and creates meaningful locally based livelihoods.

The following table shows the detailed link that the authors made between these themes of resilience and how they are related to the identified resilience dimensions:

Table 3. Themes of resilience and their relationships natural hazard resilience according to [61] HBR= Historic building environment resilience; CR= Cultural resilience; SR=Social resilience; GIR=Governance and institutional resilience; ER=Economic resilience; ENR= Environmental resilience).

Theme definition		Description of theme	Relationship to resilience	URBAN HERITAGE RESILIENCE DIMENSIONS					
				HBR	CR	SR	GIR	ECR	ENR
Social character	The social characteristics of the community.	Represents the social and demographic factors that influence the ability to prepare for and recover from a natural hazard event.	Gender, age, disability, health, household size and structure, language, literacy, education and employment influence abilities to build disaster resilience [71,72]		■	■			
Social and community engagement	The capacity within communities to learn, adapt and transform.	Represents the social enablers within communities for engagement, learning, adaptation and transformation.	Cooperation and trust are essential to building disaster resilience and arise partly through social mechanisms including social capital [60,73]			■	■		
			Behavioral change has a social and cultural context [74,75]		■	■			
Community capital	The cohesion and connectedness of the community.	Represents the features of a community that facilitate coordination and cooperation for mutual benefit.	Social networks assist community recovery following disaster [76]			■			
			Bonding, bridging and linking social capital can enhance solutions to collective action problems that arise following natural disasters [77]			■			
Economic capital	The economic characteristics of the community	Represents the economic factors that influence the ability to prepare for and recover from a natural hazard event.	Access to economic capital may be a barrier to resilience [78]					■	
			Economic capital often supports healthy social capital [72]			■		■	
Infrastructure and planning	The presence of legislation, plans, structures or codes to	Represents preparation for natural hazard events using strategies of mitigation or	Considered siting and planning of infrastructure is an important element of hazard mitigation. Multiple levels of government are	■			■		

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	protect infrastructure and ensure service availability.	planning or risk management.	involved in the planning process [79,80]	
			Planners can be agents of change in building disaster resilience [81]	
Emergency services	The presence of emergency services and disaster response plans.	Represents the potential to respond to a natural hazard event.	Emergency response capabilities and systems support resilience through the prevention, preparedness, response and recovery cycle [82]	
Information and engagement	Availability and accessibility of natural hazard information and community engagement to encourage risk awareness.	Represents the relationship between communities and information, the uptake of information about risks and the knowledge required for preparation and self-reliance.	Emergency management community engagement comprises different approaches including information, participation, consultation, collaboration and empowerment.	
			Community engagement is a vehicle of public participation in decision making about natural hazards [83]	
Governance, policy and leadership	The capacity within government agencies to learn, adapt and transform.	Represents the flexibility within organizations to adaptively learn, review and adjust policies and procedures, or to transform organizational practices.	Effective response to natural hazard events can be facilitated by long term design efforts in public leadership [84,85]	
			Transformative adaptation requires altering fundamental value systems, regulatory or bureaucratic regimes associated with natural hazard management [86]	
			Collaborative learning facilitates innovation and opportunity for feedback and iterative management [65,87]	

A heritage-centred resilience vision should aim to be community-based, culture-driven, socially just, and economically viable, while integrating local, traditional knowledge as well as local ecosystems and resources. Such a vision should reuse and adapt approaches from already more developed fields whenever possible, only developing new heritage-specific approaches when the singularity of urban heritage makes this mandatory. The following table shows the identified dimensions of resilience, suggestions for their operationalization from SHELTER and ARCH, and the singularity in cultural heritage of the dimension (see **Error! Reference source not found.**):

Table 3. Dimensions and SHELTER approach

DIMENSION	Suggestions for operationalization	SINGULARITY
Historic building environment resilience	Including the physical vulnerability of the historic built environment as a nested concept for general resilience, vernacular architecture as catalyst of heritage-led resilience by capitalizing on its intrinsic characteristics, and considering the singularities of the built environment for conservation-friendly planning	Very High
Cultural resilience	Considering tangible and intangible cultural heritage as key driver in urban heritage resilience, fostering identity and sense of place, stimulating social cohesion through cultural activities and traditions, and safeguarding traditional knowledge and practices. Cultural diversity has the capacity to increase the	Very High

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	resilience of social systems, since it is the result of centuries of slow adaptation to the hazards that affect local environments.	
Social resilience	Considering social memory as key part of historic area resilience. Vulnerable groups (elderly, migrants, children, disabled) are specifically considered and the gender perspective is transversal.	High
Governance and institutional resilience	Adoption of adaptive governance approaches that include cross-departmental, cross-sectoral, and cross-scale collaboration, increased community participation, and collaboration with relevant external actors (e.g., NGOs) and special interest groups.	High
Economic resilience	Foster the innovation and competitive advantage of the local and regional economic sectors while making use of local materials and practices, valorising local knowledge of craftsmen and artisans, as well as incentivizing solutions from the local cultural sector.	Medium
Environmental resilience	Proposing circular approaches that reuse local materials and renewable resources and take advantage of the historic adaptation to local climate and circumstances.	Medium

2.5 Requirements for a Framework to Operationalize Urban Heritage Resilience.

Based on the above analyses and comparisons, any framework aimed at operationalizing urban heritage resilience needs to take the multidimensionality of resilience and the social-ecological-technical system nature of urban heritage into account. Such a framework would also need to consider the long-term adaptive and transformative characteristics of a resilient system as well as the need to maintain and return to a functional state in the short-term. The adaptive cycle [25,88,89] provides the ideal base for such a framework as it focuses on the dynamics of systems that do not have an equilibrium state, but repeatedly pass through four phases: growth and exploitation; conservation; collapse or release; and renewal and reorganization. Here, the shifts between phases can be the result of gradual changes or shocks. Urban heritage resilience then describes how an urban heritage system reacts to these changes and shocks as well as its long-term development path. It can be expressed in terms of a system's robustness and rate of recovery[90]. A system's robustness is determined according to its ability to absorb disturbances before losing its identity. At the same time, its rate of recovery can be expressed as the flexibility and the time needed to rearrange itself into a new stable state after a disturbance occurs (see **Error! Reference source not found.**).

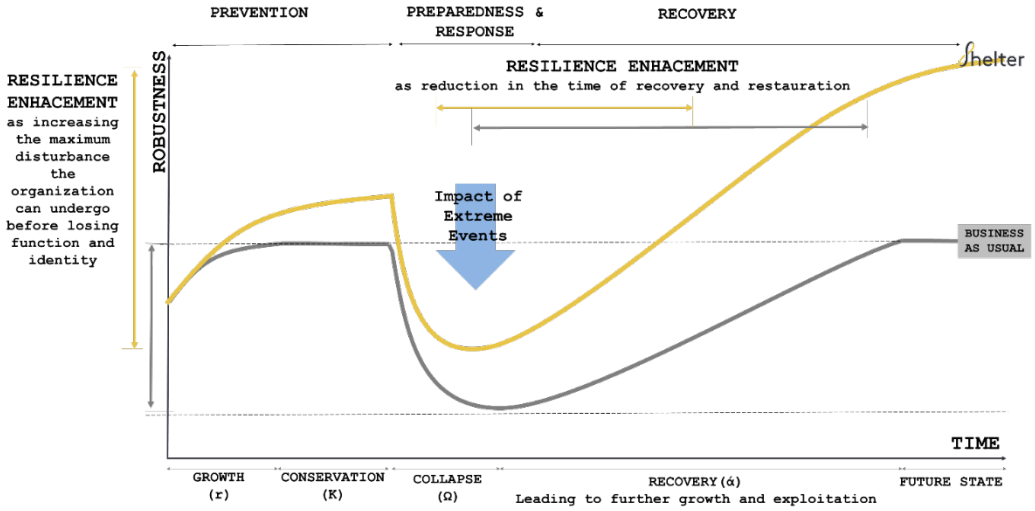

Figure 1. Enhancement of resilience as improvement of HA's robustness and rapidity (adapted from [91])

It follows that a framework for urban heritage resilience needs to increase the robustness of the urban heritage system as well as reduce the time this system needs to recover and be restored, both

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under slow-onset stresses and sudden-onset disasters. Thus, it becomes evident that an urban heritage framework should combine an adaptation / prevention-preparedness cycle (as in climate change adaptation) and a response-recovery cycle (as in disaster risk management). To make such a framework operational it requires the integration of suitable methods, tools, and strategies that positively impact on urban heritage resilience in different phases of the cycles and consistently consider the different resilience dimensions.

3.Results

3.1. Urban Heritage Resilience in SHELTER and ARCH

Resilience in historic environments within SHELTER and ARCH has been defined as seen in **Error! Reference source not found.**.

Table 4. Resilience definitions from SHELTER and ARCH

Resilience in SHELTER	Resilience in ARCH
"[T]he ability of a historic urban or territorial system-and all its social, cultural, economic, environmental dimensions across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and use it for a systemic transformation to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to adapt in order to maintain the same identity"	*"The sustained ability of a historic area as a social-ecological system (including its social, cultural, political, economic, natural, and environmental dimensions) to cope with hazardous events by responding and adapting in socially just ways that maintain the historic area's functions and heritage significance (including identity, integrity, and authenticity)."*

Both definitions are complementary and acknowledge the multidimensional and the cross-scalar nature of the resilience in historic environment. These environments are seen as socio-ecological systems, requiring heritage-led resilience that leverages their inherent traits like self-learning, circular economy, and sustainability. Conservation-friendly resilience is essential to balance cultural identity preservation with adaptation to new needs. Responses must be socially just, addressing community vulnerabilities and power imbalances without worsening inequalities. Finally, resilience planning must consider different temporal and spatial scales.

3.2. The SHELTER and ARCH Frameworks

Both the SHELTER framework (Figure 2) and ARCH framework (Figure 3) provide integrated and operational approaches for urban heritage resilience. They both integrate the disaster risk management (prevention, preparedness, response and recovery) and climate change adaptation planning processes in complementary and mutually strengthening circular processes. SHELTER adopts the adaptive cycle approach to combine disaster risk management and climate change adaptation. It also links its framework with thematic areas relevant for urban resilience planning: existing data and knowledge, assessment and monitoring, tools, solutions, planning, and policies. The SHELTER framework is based on a matrix acting as a canvas that is the result of the intersection between the four phases of disaster risk management and the tools and mechanisms that support resilience building in historic environments. ARCH on the other hand is based on the cyclical structure of the DRM framework from Jigyasu, King, and Wijesuriya [92] and the climate change adaptation cycle of the Urban Adaptation Support Tool [93]. It consists of ten cyclical steps spread across the three phases 'pre-disaster', 'during', 'post-disaster'. In addition, the ARCH framework acknowledges that the results of some steps might need to be revised in case of the occurrence of a disaster to facilitate the recovery process, i.e., ARCH integrates the adaptive cycle approach in a more indirect way than SHELTER.

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Both frameworks advocate for conducting vulnerability and risk assessments both for slow-onset climatic risks as well as sudden-onset risks from, e.g., natural disasters, as required by the calls for more harmonization between CCA and DRM from the policy level. Similarly, based on these analyses, not only CCA measures, but also risk prevention and mitigation measures, as well as emergency response measures should be identified, assessed, selected, and implemented. Both frameworks also advocate for the establishment of a monitoring, evaluation, and learning framework, not just cover monitoring of the implementation effort but also progress of the combined DRM / CCA process, enabling a feedback loop of learning processes that allows to adjust goals and processes. Lastly, both frameworks also suggest a revision of the results from the normal operating phase as part of the recovery after a disaster to account for the need to adjust information and actions identified under normal conditions with the post-disaster situation.

Both frameworks provided the basis for a combined CEN Workshop Agreement (CWA)[94] under the participation of project partners and external participants. For each step, the CWA proposes requirements that decision makers have to fulfil, recommendations that could be performed, indicators to measure progress in building resilience and supporting guidelines, tools, and standards that help to progress within each resilience-building step.

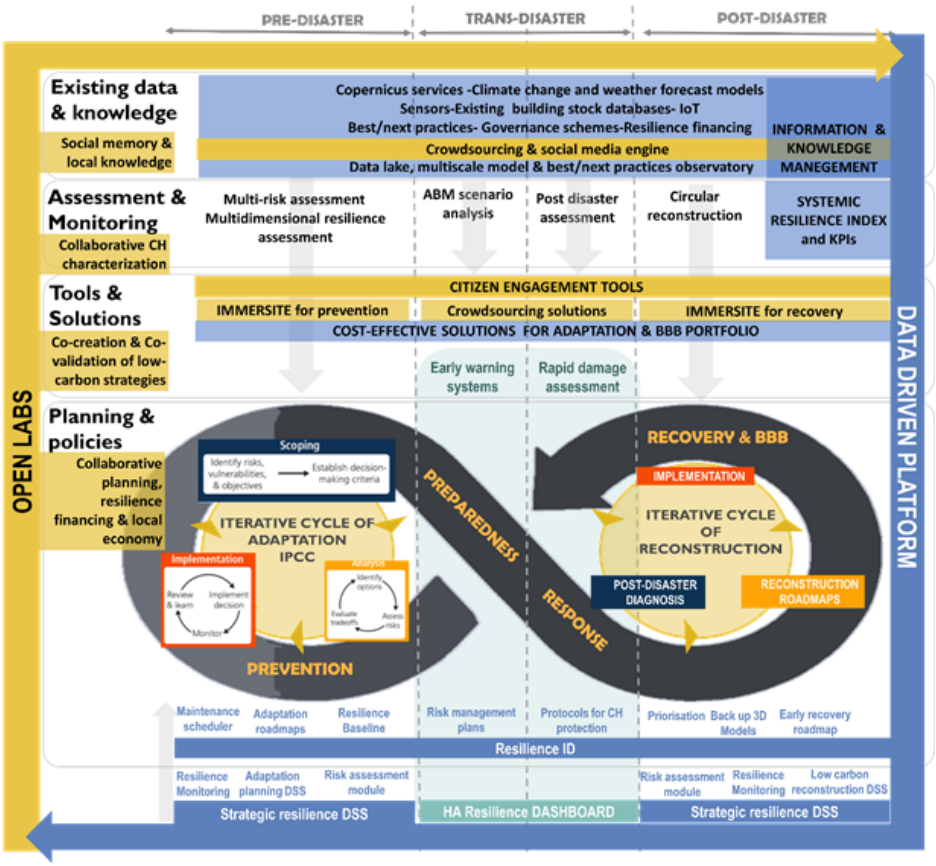

Figure 2. SHELTER Operational knowledge framework

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Figure 3: ARCH Resilience Framework

With their focus on a holistic process, SHELTER and ARCH integrate the notion of generalized resilience ("all-hazards approach") with specific resilience (assessing and addressing risks of specific hazards). More specifically, both frameworks advertise for:

- Proper data acquisition and management, system analysis and scenario definition, including the identification and integration of multiple data sources (satellite, sensors, crowdsourcing, predictive models, statistic models…) and existing knowledge (including local social memory regarding past events, best practices and results...) as the basis for any resilience building process.
- Risk and resilience assessments that include direct and indirect impacts of events on cultural assets (i.e., from physical damage and degradation of sites to socio-cultural, environmental and socio-economic dimensions) and consider sensitiveness, adaptive capacity as well as exposure to a specific or to a combination of multiple hazards.
- Identification and assessment of risk prevention, mitigation, climate change adaptation, and emergency response measures that take the need of urban heritage into account and allow for adaptive policy making.
- Decision-making based on adaptation pathways that can include conservation-friendly multifunctional solutions as the implementation of NBS and local solutions.
- Monitoring and learning processes, covering technical early warning systems as well as regular re-assessments and adaptation of plans, if necessary

Across all these steps, SHELTER and ARCH require the implementation of community-based and heritage-led approaches that facilitate the effective collaboration of local, regional, national, and international stakeholders and increase the capacity of local communities to prepare for and react to a disaster. This includes suitable documentation strategies that allow to make relevant information, e.g., on pre-planned early recovery roadmaps in trans-disaster and post-disaster phases, and codified social memory, i.e., local experience to dealing with past disasters, available to a broad range of stakeholders. This also includes supporting stakeholders in being prepared for the challenges of climate change and natural hazards by collecting and exchanging best practices, lessons learnt and next practices in the field of urban heritage, increasing awareness and understanding of response options and interdependencies in a peer learning environment.

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3.3. Further operationalizing urban heritage resilience through dedicated tools

To further translate the operational aspect of the SHELTER and ARCH frameworks into actionable and context-specific strategies for urban heritage resilience, it is necessary to develop dedicated tools and methods for each step of the resilience building process. These tools and methods need to facilitate the collection, analysis, and dissemination of relevant information and knowledge, the assessment of risks and resilience, as well as support the strategic decision making of stakeholders. Both SHLTER and ARCH provided such tools and methods, the main components of which are:

Information and Knowledge Management:

The models and data needed to make informed decisions around urban heritage resilience are not always readily available in a format that is usable for decision-makers. Data lakes and information management systems like the SHELTER Data Lake and the ARCH Historic Area Information System / Threats and Hazard Information System provide the basis to combine heterogeneous data (satellite imagery, sensor data, geo-environmental and social big data, existing building and disaster databases and crowdsourcing). These systems require a multiscale data model to structure all information available on local, regional, national, and European level, ideally compliant with existing data models (e.g., INSPIRE). These information management systems for the state of the urban area and the hazards potentially affecting these areas need to be supplemented by databases that provide structured information on potential resilience enhancing measures, including local and traditional knowledge from the communities, assessed for their cost-effectiveness, their potential effects on the heritage values, and co-benefits for climate change mitigation and sustainable development. Such databases are provided by the SHELTER portfolio and the ARCH Resilience Measures Inventory.

These information and knowledge management methods and tools provide the basis for all steps and phases (prevention, preparedness, response and recovery) of resilience building.

Risk and Resilience Assessment:

Improving the resilience of an urban areas requires the assessment of specific (risk) and generalized resilience on multiple levels – from building-/structure-level to city-/region-level. Risk assessments need to be able to consider multiple, potentially compounding hazards, and support not only quantitative assessment (e.g., based in damage functions), but also expert-knowledge-based assessments, where quantifiable data is not available – which is often the case for cultural heritage, where the intrinsic value ascribed to the heritage by the local community needs to be captured. Resilience assessments on the other hand need to cover a multitude of topics, from organizational / governance aspects to financial capacities, to training and education capacities, and heritage management perspectives. This requires an iterative, multi-stakeholder assessment approach that allows incrementally analysing different aspects of the resilience maturity as new knowledge becomes available. Both SHELTER and ARCH provide different, but complimentary approaches for these problems. While SHELTER [Insert something about SHELTER multi-risk assessment]. ARCH on the other hand follows a semi-quantitative, indicator-based risk assessment approach, based on impact chains [95]– cause-effect models that describe the relationship between different hazards, the elements exposed to these hazards, their sensitivities and capacities, and how these lead to (cascading) impacts and subsequently to risk. These models are usually created in multi-stakeholder workshops, making use of the local expert knowledge, and are then quantified using indicator data, provided by the information management systems. Resilience assessment in SHELTER [insert something about the Resilience Dashboard] In ARCH, a scorecard approach is employed for resilience assessments, i.e., a structured online questionnaire for multi-stakeholder self-assessments. The core of the ARCH Resilience Assessment Dashboard (RAD) are 221 questions, categorized into ten overarching Essentials – an adapted version of the Ten Essential for Making Cities Resilient [9] – three disaster risk management phases, four topics (disaster risk management, climate change adaptation, heritage management, social justice), and six resilience dimensions (built environment,

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natural environment, economy, policy, society, and culture). Each question is answered on a 6-point Likert scale and supported by explanatory information, including potential stakeholders who have the information needed to answer the question. The RAD provides users with a score, which indicates the performance in the different aspects relevant to building resilience. By analysing the results, users can identify weak points in the resilience of the historic area. Based on these results, users can formulate a list of actions for increasing the resilience.

Based on the results from the risk and resilience assessments, resilience enhancing measures need to be identified and collated into implementable action plans.

Strategic Decision Support

Once risk and resilience weak spots have been identified, suitable measures to address these weak spots need to be selected (e.g., from the SHELTER portfolio or the ARCH Resilience Measures Inventory). These measures need to be bundled together in a way that allows effective and efficient implementation and then be sequenced over time to allow for adaptive planning. SHELTER support this by providing a strategic and spatially explicit decision-making tool (the SHELTER DSS [96]). The DSS combines:

- The multi-risk assessment module for diagnosis and prioritisation (identifying "hot spots") based on the multiscale data model and the data lake.
- A DSS for planning adaptation and building back better that will combine the information from the multi-risk module and the solutions portfolio.

ARCH supports this process via the Resilience Pathway Visualisation Tool (RPVT), a web-based tool that allows to visually construct implementation pathways for resilience measures, i.e., which resilience measures must be implemented in which sequence to raise the resilience to a certain level until a certain time. It also allows to assess and compare alternative resilience pathways.

3.4. Changing roles of Urban Cultural Heritage Throughout the Four Different Phases

Cultural heritage is on a global scale increasingly frequent affected by disasters (e.g., flooding, earthquakes, fire), and crises ranging from short to long-term. Climate change being the most pressing and urgent crisis there are also economic crises or health crises [97,98][99,100]). The aims and objectives to respond to these crises vary according to their specific scope and nature. As we have already seen, the SHELTER and ARCH concepts of resilience are structured in four phases: Prevention, Preparedness, Recovery and Build Back Better. In each of the phases, different entities and processes are relevant to enhance resilience. The diversification of resilience into these four different phases considers the different contexts and different needs in each resilience phase, which can help to enhance the understanding of which expertise, decisions, skills, resources etc. are relevant in each phase (and are not the same in each phase). Building on these four the objectives and potential roles of cultural heritage have also been diversified (Table 5).

Table 5. Potential Role of Cultural Heritage in the Shelter Concept of Resilience. Based on [99,100] and own considerations [2].

Shelter Concept Phase of Resilience	Potential Objectives	Potential Role of cultural heritage
Prevention	Avoid disaster and crisis	Context/ Element of the Scoping
Preparedness	Enhance Preparation for potential disaster and crisis	Asset to be protected
Response	Emergency Reactions	Resource
Recovery and BBB	Increase the Quality of life for local communities	Resource

Table 5**Error! Reference source not found.** is showing the role of cultural heritage in the four resilience phases based on the Shelter Concept of Resilience. This more refined understanding

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expands the often used narrative that Cultural Heritage is only made of objects (buildings mainly) that are to be protected. Understanding the different resilience phases opens the door to new roles of cultural heritage. One role is a resource for resilience [101][15] another one is often a major part of the context in which disasters and crises are happening. The role of context needs to be explored more in detail but there are obvious relations like the restrictions and limitations for the use of big emergency vehicles due to small/steep historic urban street patterns for example. Or the limitation to the use of specific emergency technologies such as chemical fire extinguishers because cultural heritage could be harmed even if it isn't affected by the fire in the first place. These described changing roles of cultural heritage are reflecting well the underlying systemic logic that is apparent in the SHELTER and ARCH concepts of resilience and in a contemporary understanding of cultural heritage [45,99]) [100]

4. Conclusions

Operationalising urban heritage resilience necessitates an acceptance of a certain "fluidity," often seen in system-based approaches. These approaches do not have fixed and rigid boundaries but instead rely on perspective, timing, and context. Within these frameworks, urban heritage must assume different roles, ranging from an asset needing protection to a valuable resource for supporting resilience. This includes that the heritage sector needs to better comprehend and define its role concerning urban resilience and disaster risk management. While it is evident that disasters and transformations related to urban heritage are becoming more frequent [2], awareness and understanding of the associated risks, processes, and responsibilities among site managers and heritage officers remain quite limited. Additionally, the variety of roles that cultural heritage can play in urban resilience—such as being a resource for adaptation or providing a sense of home and well-being by serving as a stable context during times of change and disaster—are often overlooked.

Frameworks aimed at improving the operationalisation of urban heritage resilience need to acknowledge this contextual flexibility, treating urban heritage both as a resource and an asset to protect. Furthermore, these frameworks should allow practitioners a degree of freedom to tailor solutions to local contexts using system-based approaches. However, this leads to increased complexity due to higher abstraction levels compared to systems with clearly defined borders, where solutions are straightforward. This complexity was evident in initial feedback on the SHELTER framework, which, in its published form, appeared intricate and challenging to communicate to decision-makers and urban practitioners. Despite this, once understood, especially its structure with four distinct phases, the framework has proven effective in practical urban planning and management scenarios [2].

Given the flexibility required, the selection of methods and tools must be diverse to suit varying local contexts. As a result, practitioners must navigate a complex landscape of methods and strategies, each tailored to address specific aspects of resilience, further complicating the implementation process. Nevertheless, this should not lead to incompatibility among tools. Thus, there is a need for better harmonisation of foundational elements (e.g., data, information, interfaces, methods) so that different tools can operate on the same foundational data depending on local circumstances and perspectives. These tools and methods need to be gathered, explained, and be provided in a way that allows easier application by urban practitioners. This should include training, education, and capacity building to develop necessary skills and knowledge, clearly defining the roles of key players and stakeholders, and adjusting governance schemes accordingly.

The ARCH and SHELTER frameworks represent progress in this area but have been limited to real-world applications within European research projects. Despite their use in nine diverse pilot sites—each differing in size, hazards, heritage assets, and governance methods—these frameworks and their lessons now need broader application. They should be adapted as needed and consistently implemented across different local settings to become fully operational.

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